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Applicant : JIAN, Benjamin

App. No. : 09/327,826

Filed : June 8, 1999

For : MULTILAYER OPTICAL FIBER COUPLER

Examiner : NGO, HUNG

Group Art Unit 2874

**CERTIFICATE OF MAILING UNDER
37 C.F.R. §1.8**

I hereby certify that this document is being deposited this day in the U.S. Postal Service as first class mail, in an envelope addressed to:

Assistant Commissioner for Patents,
Washington, DC 20231

Date: June 27, 2001

Signature:

Name: James D. McFarland, Reg. No. 32,544

RESPONSE TO NOTICE OF NON-COMPLIANT AMENDMENT

Assistant Commissioner for Patents
Washington, DC 20231

Dear Sir:

In response to the Notice dated June 15, 2001, Applicant submits herewith a clean version of the amended claims to supplement the response filed May 29, 2001.

b1 2. The optical fiber coupler of claim 5 wherein said optical fiber comprises a single mode optical fiber.

3. The optical fiber coupler of claim 5 wherein said first layer comprises substantially single-crystal silicon.

4. The optical fiber coupler of claim 5 wherein said second layer comprises silicon.

5. A multilayer optical fiber coupler for coupling optical radiation between an optical device and an optical fiber, comprising:

a first layer, said first layer defining a fiber socket formed by photolithographic masking and etching to extend through said first layer, said fiber socket sized to receive and align said optical fiber therein;

a second layer bonded to said first layer;

said optical fiber having an end section that extends through the fiber socket, said optical fiber terminating at an end face situated approximately adjacent to the second layer, said fiber socket aligning and positioning said optical fiber therein; and

wherein said second layer has an index of refraction substantially equal to the index of refraction of the core of said optical fiber.

b2 6. A multilayer optical fiber coupler for coupling optical radiation between an optical device and an optical fiber, comprising:

a first layer, said first layer defining a fiber socket formed by photolithographic masking and etching to extend through said first layer, said fiber socket sized to receive and align said optical fiber therein;

a second layer bonded to said first layer;

said optical fiber having an end section that extends through the fiber socket, said optical fiber terminating at an end face situated approximately adjacent to the second layer, said fiber socket aligning and positioning said optical fiber therein; and

an epoxy that fills the gap between the end face of the optical fiber and the adjacent portion of the second layer, said epoxy having an index of refraction that approximately matches the index of the optical fiber so that optical losses are reduced.

7 8. A multilayer optical fiber coupler for coupling optical radiation between an optical device and an optical fiber, comprising:

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a first layer, said first layer defining a fiber socket formed by photolithographic masking and etching to extend through said first layer, said fiber socket sized to receive and align said optical fiber therein;
a second layer bonded to said first layer;
said optical fiber having an end section that extends through the fiber socket, said optical fiber terminating at an end face situated approximately adjacent to the second layer, said fiber socket aligning and positioning said optical fiber therein; and
an optical device integrated into said second layer.

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11-12. The optical fiber coupler of claim 10 wherein said optical focusing element has a focal point for optical radiation from the optical device, said optical fiber includes a core and a cladding surrounding said core, and said focal point is approximately situated along the central axis of said fiber socket, so that the optical radiation is coupled into said core of said optical fiber.

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10-15. A multilayer optical fiber coupler for coupling optical radiation between an optical device and an optical fiber, comprising:

a first layer, said first layer defining a fiber socket formed by photolithographic masking and etching to extend through said first layer, said fiber socket sized to receive and align said optical fiber therein;

a second layer bonded to said first layer, wherein said second layer comprises an optical focusing element arranged to couple optical radiation with said optical fiber;

said optical fiber having an end section that extends through the fiber socket, said optical fiber terminating at an end face situated approximately adjacent to the second layer, said fiber socket aligning and positioning said optical fiber therein; and

wherein said optical focusing element comprises a gradient-index lens.

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16. A multilayer optical fiber coupler for coupling optical radiation between an optical device and an optical fiber, comprising:

a first layer, said first layer defining a fiber socket formed by photolithographic masking and etching to extend through said first layer, said fiber socket sized to receive and align said optical fiber therein;

a second layer bonded to said first layer, wherein said second layer comprises an optical focusing element arranged to couple optical radiation with said optical fiber;

said optical fiber having an end section that extends through the fiber socket, said optical fiber terminating at an end face situated approximately adjacent to the second layer,

said fiber socket aligning and positioning said optical fiber therein; and
wherein said optical focusing element comprises a diffractive lens.

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14 **17.** A multilayer optical fiber coupler for coupling optical radiation between an optical device and an optical fiber, comprising:

a first layer, said first layer defining a fiber socket formed by photolithographic masking and etching to extend through said first layer, said fiber socket sized to receive and align said optical fiber therein;

a second layer bonded to said first layer;

said optical fiber having an end section that extends through the fiber socket, said optical fiber terminating at an end face situated approximately adjacent to the second layer, said fiber socket aligning and positioning said optical fiber therein; and

a third layer bonded to said second layer, said third layer comprising an optical device.

18 **22.** A method for making a plurality of monolithic optical fiber couplers that align an

B5 optical fiber that have a predetermined diameter, comprising:

photolithographically masking and etching a first layer to form a plurality of through holes through the first layer, thereby forming a plurality of cylindrical fiber sockets in a predetermined configuration, said fiber sockets having a diameter approximately equal to the diameter of the optical fiber;

bonding said first layer to a second layer together to provide a composite wafer;
dicing said composite wafer into a plurality of chips, each chip including one or more fiber sockets;

affixing optical fibers into said fiber sockets;

forming a plurality of VCSELs in said second layer in a predetermined configuration corresponding to the configuration of said fiber sockets; and

aligning said first layer with said second layer so that said VCSELs are aligned with said fiber sockets, and then performing said step of bonding said first and second layers together to provide said composite wafer.

19 **23.** A method for making a plurality of monolithic optical fiber couplers that align an optical fiber that have a predetermined diameter, comprising:

photolithographically masking and etching a first layer to form a plurality of through holes through the first layer, thereby forming a plurality of cylindrical fiber sockets in a predetermined configuration, said fiber sockets having a diameter

approximately equal to the diameter of the optical fiber;
bonding said first layer to a second layer together to provide a composite wafer;
dicing said composite wafer into a plurality of chips, each chip including one or
more fiber sockets;
affixing optical fibers into said fiber sockets;
forming a plurality of photodetectors in said second layer in a predetermined
configuration corresponding to the configuration of said fiber sockets; and
aligning said first layer with said second layer so that said photodetectors are
aligned with said fiber sockets, and then performing said step of bonding said first and
second layers together to provide said composite wafer.

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cont.
20 24. A method for making a plurality of monolithic optical fiber couplers that align an
optical fiber that have a predetermined diameter, comprising:

photolithographically masking and etching a first layer to form a plurality of
through holes through the first layer, thereby forming a plurality of cylindrical fiber
sockets in a predetermined configuration, said fiber sockets having a diameter
approximately equal to the diameter of the optical fiber;
bonding said first layer to a second layer together to provide a composite wafer;
dicing said composite wafer into a plurality of chips, each chip including one or
more fiber sockets;
affixing optical fibers into said fiber sockets;
forming a plurality of optical focusing elements in said second layer in a
predetermined configuration corresponding to the configuration of said fiber sockets; and
aligning said first layer with said second layer so that said optical focusing
elements are aligned with said fiber sockets, and then performing said step of bonding said
first and second layers together to provide said composite wafer.

21 25. A method for making a plurality of monolithic optical fiber couplers that align an
optical fiber that have a predetermined diameter, comprising:

photolithographically masking and etching a first layer to form a plurality of
through holes through the first layer, thereby forming a plurality of cylindrical fiber
sockets in a predetermined configuration, said fiber sockets having a diameter
approximately equal to the diameter of the optical fiber;
bonding said first layer to a second layer together to provide a composite wafer;
dicing said composite wafer into a plurality of chips, each chip including one or
more fiber sockets;

affixing optical fibers into said fiber sockets; and
wherein said step of forming said plurality of optical focusing elements comprises
forming refractive lenses.

22 20. A method for making a plurality of monolithic optical fiber couplers that align an
optical fiber that have a predetermined diameter, comprising:

photolithographically masking and etching a first layer to form a plurality of
through holes through the first layer, thereby forming a plurality of cylindrical fiber
sockets in a predetermined configuration, said fiber sockets having a diameter
approximately equal to the diameter of the optical fiber;

bonding said first layer to a second layer together to provide a composite wafer;
dicing said composite wafer into a plurality of chips, each chip including one or
more fiber sockets;

affixing optical fibers into said fiber sockets; and
wherein said step of forming said plurality of optical focusing elements comprises
forming diffractive lenses.

23 21. A method for making a plurality of monolithic optical fiber couplers that align an
optical fiber that have a predetermined diameter, comprising:

photolithographically masking and etching a first layer to form a plurality of
through holes through the first layer, thereby forming a plurality of cylindrical fiber
sockets in a predetermined configuration, said fiber sockets having a diameter
approximately equal to the diameter of the optical fiber;

bonding said first layer to a second layer together to provide a composite wafer;
dicing said composite wafer into a plurality of chips, each chip including one or
more fiber sockets;

affixing optical fibers into said fiber sockets; and
wherein said step of forming said plurality of optical focusing elements comprises
forming gradient-index lenses.

24 22. A method for making a plurality of monolithic optical fiber couplers that align an
optical fiber that have a predetermined diameter, comprising:

photolithographically masking and etching a first layer to form a plurality of
through holes through the first layer, thereby forming a plurality of cylindrical fiber
sockets in a predetermined configuration, said fiber sockets having a diameter
approximately equal to the diameter of the optical fiber;

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bonding said first layer to a second layer together to provide a composite wafer;
dicing said composite wafer into a plurality of chips, each chip including one or
more fiber sockets;
affixing optical fibers into said fiber sockets; and
wherein said second layer comprises an optical material that has an index of
refraction substantially equal to the index of refraction of said optical fiber, and said step
of affixing said optical fibers into said fiber sockets includes applying an epoxy that
approximately matches the index of refraction of said optical fiber into the fiber sockets to
fill the gap between adjacent sections of said second layer and said optical fiber.

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29. A method for making a plurality of monolithic optical fiber couplers that align an
optical fiber that have a predetermined diameter, comprising:

photolithographically masking and etching a first layer to form a plurality of
through holes through the first layer, thereby forming a plurality of cylindrical fiber
sockets in a predetermined configuration, said fiber sockets having a diameter
approximately equal to the diameter of the optical fiber;

bonding said first layer to a second layer together to provide a composite wafer;
dicing said composite wafer into a plurality of chips, each chip including one or
more fiber sockets;

affixing optical fibers into said fiber sockets; and

wherein said step of bonding said first and second layers comprises anodic
bonding.

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30. A method for making a plurality of monolithic optical fiber couplers that align an
optical fiber that have a predetermined diameter, comprising:

photolithographically masking and etching a first layer to form a plurality of
through holes through the first layer, thereby forming a plurality of cylindrical fiber
sockets in a predetermined configuration, said fiber sockets having a diameter
approximately equal to the diameter of the optical fiber;

bonding said first layer to a second layer together to provide a composite wafer;
dicing said composite wafer into a plurality of chips, each chip including one or
more fiber sockets;

affixing optical fibers into said fiber sockets; and

wherein said step of bonding said first and second layers comprises epoxy
bonding.

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31. A method for making a plurality of monolithic optical fiber couplers that align an



optical fiber that have a predetermined diameter, comprising:

photolithographically masking and etching a first layer to form a plurality of through holes through the first layer, thereby forming a plurality of cylindrical fiber sockets in a predetermined configuration, said fiber sockets having a diameter approximately equal to the diameter of the optical fiber;

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bonding said first layer to a second layer together to provide a composite wafer;
dicing said composite wafer into a plurality of chips, each chip including one or more fiber sockets;

affixing optical fibers into said fiber sockets; and

wherein said step of bonding said first and second layers comprises metal solder bonding.

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32. A method for making a plurality of monolithic optical fiber couplers that align an optical fiber that have a predetermined diameter, comprising:

photolithographically masking and etching a first layer to form a plurality of through holes through the first layer, thereby forming a plurality of cylindrical fiber sockets in a predetermined configuration, said fiber sockets having a diameter approximately equal to the diameter of the optical fiber;

bonding said first layer to a second layer together to provide a composite wafer;
dicing said composite wafer into a plurality of chips, each chip including one or more fiber sockets;

affixing optical fibers into said fiber sockets; and

wherein said dicing step comprises cutting partially through said composite wafer, then performing said affixing step to affix optical fibers to said fiber sockets, and then physically separating said composite wafer into chips, each of which comprises one or more optical couplers.

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33. A method for making a plurality of monolithic optical fiber couplers that align an optical fiber that have a predetermined diameter, comprising:

photolithographically masking and etching a first layer to form a plurality of through holes through the first layer, thereby forming a plurality of cylindrical fiber sockets in a predetermined configuration, said fiber sockets having a diameter approximately equal to the diameter of the optical fiber;

bonding said first layer to a second layer together to provide a composite wafer;
dicing said composite wafer into a plurality of chips, each chip including one or more fiber sockets;

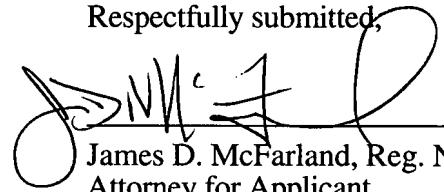
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affixing optical fibers into said fiber sockets; and
bonding a third layer that comprises an optical device to said second layer.

No fee is believed due; however in the event that additional fees are required, the Commissioner is hereby authorized to charge any additional fees that may be required to Deposit Account No. 50-0948. If an extension of time is required, then Applicant requests such extension.

Respectfully submitted,

Dated: June 27, 2001



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